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PATENT TRADEMARK OFFICE

CHAPTER II

TRANSMITTAL LETTER TO THE UNITED STATES ELECTED OFFICE (EO/US) (ENTRY INTO U.S. NATIONAL PHASE UNDER CHAPTER II)

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB99/03425	22 OCTOBER 1999	23 OCTOBER 1998

TITLE OF INVENTION
METHOD AND APPARATUS FOR REDUCING DISTORTION OF DIGITAL DATA

APPLICANT(S)
1. HERBERT BRIAN BEECH
2. DAVID EDWARDS

Box PCT
Assistant Commissioner for Patents
Washington D.C. 20231
ATTENTION: EO/US

NOTE: The completion of those filing requirements that can be made at a time later than 30 months from the priority date results from the Commissioner exercising his judgment under the authority granted under 35 USC 371(d). The filing receipt will show the actual date of receipt of the last item completing the entry into the national phase. See 37 C.F.R. §1.491 which states: "An international application enters the national state when the applicant has filed the documents and fees required by 35 USC 371(c) within the periods set forth in § 1.494 and § 1.495 "

WARNING: Where the items are those which can be submitted to complete the entry of the international application into the national phase are subsequent to 30 months from the priority date the application is still considered to be in the international state and if mailing procedures are utilized to obtain a date the express mail

CERTIFICATION UNDER 37 C.F.R. 1.10*
*(Express Mail label number is **mandatory**.)*
(Express Mail certification is optional)

I hereby certify that this correspondence and the documents referred to as attached therein are being deposited with the United States Postal Service on this date APRIL 19, 2001, in an envelope as "Express Mail Post Office to Addressee," Mailing Label Number EL 728212401 US, addressed to the: Assistant Commissioner for Patents, Washington, D.C. 20231.

BARBARA D. SANTIAGO
(type or print name of person mailing paper)

Barbara D Santiago
Signature of person mailing paper

WARNING: Certificate of mailing (first class) or facsimile transmission procedures of 37 C.F.R. 1.8 cannot be used to obtain a date of mailing or transmission for this correspondence.

WARNING: Each paper or fee filed by "Express Mail" **must have the number of the "Express Mail" mailing label placed thereon prior to mailing. 37 C.F.R. 1.10(b)*
*"Since the filing of correspondence under § 1.10 without the Express Mail mailing label thereon is an oversight that can be avoided by the exercise of reasonable care, requests for waiver of this requirement will **not** be granted on petition." Notice of Oct. 24, 1996, 60 Fed. Reg. 56,439, at 56,442.*

procedure of 37 C.F.R. §1.10 must be used (since international application papers are not covered by an ordinary certificate of mailing - See 37 C.F.R. §1.8.

NOTE. Documents and fees must be clearly identified as a submission to enter the national state under 35 USC 371 otherwise the submission will be considered as being made under 35 USC 111. 37 C.F.R. § 1.494(f).

1. Applicant herewith submits to the United States Elected Office (EO/US) the following items under 35 U.S.C. 371:

   a. [X] This express request to immediately begin national examination procedures (35 U.S.C. 371(f)).

   b. [X] The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees (37 C.F.R. § 1.492) as indicated below:

2.Fees

CLAIMS FEE	(1) FOR	(2) NUMBER FILED	(3) NUMBER EXTRA	(4) RATE	(5) CALCULATIONS
[ ]*	TOTAL CLAIMS	19 - 20 =	0	x $ 18.00 =	$
	INDEPENDENT CLAIMS	2 - 3 =	0	x $ 80.00 =	
	MULTIPLE DEPENDENT CLAIM(S) (if applicable) + $270.00				
BASIC FEE**	[ ] U.S. PTO WAS INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where an International preliminary examination fee as set forth in § 1.482 has been paid on the international application to the U.S. PTO: [ ] and the international preliminary examination report states that the criteria of novelty, inventive step (non-obviousness) and industrial activity, as defined in PCT Article 33(2) to (4) have been satisfied for all the claims presented in the application entering the national stage (37 CFR 1.492(a)(4)) ..... $100.00 [ ] and the above requirements are not met (37 CFR 1.492(a)(1)) ..... $690.00 [X] U.S. PTO WAS NOT INTERNATIONAL PRELIMINARY EXAMINATION AUTHORITY Where no international preliminary examination fee as set forth in § 1.482 has been paid to the U.S. PTO, and payment of an international search fee as set forth in § 1.445(a)(2) to the U.S. PTO: [ ] has been paid (37 CFR 1.492(a)(2)) ..... $710.00 [ ] has not been paid (37 CFR 1.492(a)(3)) ..... $1,000.00 [X] where a search report on the international application has been prepared by the European Patent Office or the Japanese Patent Office (37 CFR 1.492(a)(5)) $860.00				
	Total of above Calculations				=860.00
SMALL ENTITY	Reduction by ½ for filing by small entity, if applicable. Affidavit must be filed. (note 37 CFR 1.9, 1.27, 1.28)				-
	Subtotal				860.00
	Total National Fee				$860.00
	Fee for recording the enclosed assignment document $40.00 (37 CFR 1.21(h)). (See Item 13 below). See attached "ASSIGNMENT COVER SHEET".				
TOTAL	Total Fees enclosed				$860.00

*See attached Preliminary Amendment Reducing the Number of Claims.

i. [X] A check in the amount of $860.00 to cover the above fees is enclosed.
ii. [ ] Please charge Account No. _____ in the amount of $ _____.
A duplicate copy of this sheet is enclosed.

**WARNING: *"To avoid abandonment of the application the applicant shall furnish to the United States Patent and Trademark Office not later than the expiration of 30 months from the priority date: * * * (2) the basic national fee (see § 1.492(a)) The 30-month time limit may not be extended." 37 C.F.R. § 1.495(b).*

WARNING: If the translation of the international application and/or the oath or declaration have not been submitted by the applicant within thirty (30) months from the priority date, such requirements may be met within a time period set by the Office. 37 C.F.R. § 1.495(b)(2). The payment of the surcharge set forth in § 1.492(e) is required as a condition for accepting the oath or declaration later than thirty (30) months after the priority date. The payment of the processing fee set forth in § 1.492(f) is required for acceptance of an English translation later than thirty (30) months after the priority date. Failure to comply with these requirements will result in abandonment of the application. The provisions of § 1 136 apply to the period which is set. Notice of Jan. 3, 1993, 1147 O.G. 29 to 40.

3. [X] A copy of the International application as filed (35 U.S.C. 371(c)(2)):

NOTE: Section 1.495 (b) was amended to require that the basic national fee and a copy of the international application must be filed with the Office by 30 months from the priority date to avoid abandonment "The International Bureau normally provides the copy of the international application to the Office in accordance with PCT Article 20. At the same time, the International Bureau notifies applicant of the communication to the Office. In accordance with PCT Rule 47.1, that notice shall be accepted by all designated offices as conclusive evidence that the communication has duly taken place. Thus, if the applicant desires to enter the national stage, the applicant normally need only check to be sure the notice from the International Bureau has been received and then pay the basic national fee by 30 months from the priority date." Notice of Jan. 7, 1993, 1147 O.G 29 to 40, at 35-36. See item 14c below.

a. [ ] is transmitted herewith.
b. [ ] is not required, as the application was filed with the United States Receiving Office.
c. [X] has been transmitted
i. [X] by the International Bureau.
Date of mailing of the application (from form PCT/IB/308): _____.
ii. [ ] by applicant on _____.
Date

4. [X] A translation of the International application into the English language (35 U.S.C. 371(c)(2)):
a. [ ] is transmitted herewith.
b. [X] is not required as the application was filed in English.
c. [ ] was previously transmitted by applicant on _____.
Date
d. [ ] will follow.

09/807857

532 Rec'd PCT/PTO 19 APR 2001

5. [X] Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. 371(c)(3)):

NOTE: The Notice of January 7, 1993 points out that 37 C.F.R. § 1.495(a) was amended to clarify the existing and continuing practice that PCT Article 19 amendments must be submitted by 30 months from the priority date and this deadline may not be extended. The Notice further advises that: "The failure to do so will not result in loss of the subject matter of the PCT Article 19 amendments. Applicant may submit that subject matter in a preliminary amendment filed under section 1.121. In many cases, filing an amendment under section 1.121 is preferable since grammatical or idiomatic errors may be corrected." 1147 O.G. 29-40, at 36.

a. [ ] are transmitted herewith.
b. [ ] have been transmitted
 i. [ ] by the International Bureau.
 Date of mailing of the amendment (from form PCT/IB/308): _________.
 ii. [ ] by applicant on ____________.
 Date
c. [X] have not been transmitted as
 i. [X] applicant chose not to make amendments under PCT Article 19.
 Date of mailing of Search Report (from form PCT/ISA/210): FEB. 2, 2000.
 ii. [ ] the time limit for the submission of amendments has not yet expired. The amendments or a statement that amendments have not been made will be transmitted before the expiration of the time limit under PCT Rule 46.1.

6. [X] A translation of the amendments to the claims under PCT Article 19 (38 U.S.C. 371(c)(3)):
a. [ ] is transmitted herewith.
b. [ ] is not required as the amendments were made in the English language.
c. [X] has not been transmitted for reasons indicated at point 5(c) above.

7. [X] A copy of the international examination report (PCT/IPEA/409)
 [X] is transmitted herewith.
 [ ] is not required as the application was filed with the United States Receiving Office.

8. [X] Annex(es) to the international preliminary examination report
a. [X] is/are transmitted herewith.
b. [ ] is/are not required as the application was filed with the United States Receiving Office.

9. [X] A translation of the annexes to the international preliminary examination report
a. [ ] is transmitted herewith.
b. [X] is not required as the annexes are in the English language.

10. [X] An oath or declaration of the inventor (35 U.S.C. 371(c)(4)) complying with 35 U.S.C. 115

a. [ ] was previously submitted by applicant on _____. Date

b. [X] is submitted herewith, and such oath or declaration

i. [ ] is attached to the application.

ii. [X] identifies the application and any amendments under PCT Article 19 that were transmitted as stated in points 3(b) or 3(c) and 5(b); and states that they were reviewed by the inventor as required by 37 C.F.R. 1.70.

c. [ ] will follow.

Other document(s) or information included:

11. [X] An International Search Report (PCT/ISA/210) or Declaration under PCT Article 17(2)(a):

a. [X] is transmitted herewith.

b. [ ] has been transmitted by the International Bureau.
Date of mailing (from form PCT/IB/308): _____.

c. [ ] is not required, as the application was searched by the United States International Searching Authority.

d. [ ] will be transmitted promptly upon request.

e. [ ] has been submitted by applicant on _____. Date

12. [X] An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98:

a. [X] is transmitted herewith.
Also transmitted herewith is/are:
[X] Form PTO-1449 (PTO/SB/08A and 08B).
[X] Copies of citations listed.

b. [ ] will be transmitted within THREE MONTHS of the date of submission of requirements under 35 U.S.C. 371(c).

c. [ ] was previously submitted by applicant on _____. Date

13. [X] An assignment document is transmitted herewith for recording.

A separate [X] "COVER SHEET FOR ASSIGNMENT (DOCUMENT) ACCOMPANYING NEW PATENT APPLICATION" or [ ] FORM PTO 1595 is also attached.

_____

_____

_____

14. [X] Additional documents:
    a. [ ] Copy of request (PCT/RO/101)
    b. [X] International Publication No. WO 00/25495
        i. [X] Specification, claims and drawing
        ii. [ ] Front page only
    c. [X] Preliminary amendment (37 C.F.R. § 1.121)
    d. [X] Other

FORM PCT/IB/306

15. [X] The above checked items are being transmitted
    a. [X] before 30 months from any claimed priority date.
    b. [ ] after 30 months.

16. [ ] Certain requirements under 35 U.S.C. 371 were previously submitted by the applicant on _____, namely:

AUTHORIZATION TO CHARGE ADDITIONAL FEES

WARNING: *Accurately count claims, especially multiple dependent claims, to avoid unexpected high charges if extra claims are authorized.*

NOTE: "A written request may be submitted in an application that is an authorization to treat any concurrent or future reply, requiring a petition for an extension of time under this paragraph for its timely submission, as incorporating a petition for extension of time for the appropriate length of time. An authorization to charge all required fees, fees under § 1.17, or all required extension of time fees will be treated as a constructive petition for an extension of time in any concurrent or future reply requiring a petition for an extension of time under this paragraph for its timely submission. Submission of the fee set forth in § 1.17(a) will also be treated as a constructive petition for an extension of time in any concurrent reply requiring a petition for an extension of time under this paragraph for its timely submission." 37 C.F.R. § 1.136(a)(3).

NOTE: "Amounts of twenty-five dollars or less will not be returned unless specifically requested within a reasonable time, nor will the payer be notified of such amounts; amounts over twenty-five dollars may be returned by check or, if requested, by credit to a deposit account." 37 C.F.R. § 1.26(a).

[X] The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to Account No. 12-0425.

[X] 37 C.F.R. 1.492(a)(1), (2), (3), and (4) (filing fees)

WARNING: *Because failure to pay the national fee within 30 months without extension (37 C.F.R. § 1.495(b)(2)) results in abandonment of the application, it would be best to always check the above box*

[ ] 37 C.F.R. 1.492(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must

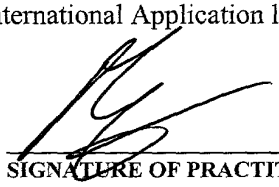
only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 C.F.R. § 1 492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possible when dealing with amendments after final action.

[X] 37 C.F.R. 1.17 (application processing fees)
[X] 37 C.F.R. 1.17(a)(1)-(5)(extension fees pursuant to § 1.136(a).
[X] 37 C.F.R. 1.18 (issue fee at or before mailing of Notice of Allowance, pursuant to 37 C.F.R. 1.311(b))

NOTE: Where an authorization to charge the issue fee to a deposit account has been filed before the mailing of a Notice of Allowance, the issue fee will be automatically charged to the deposit account at the time of mailing the notice of allowance. 37 C.F.R. § 1.311(b).

NOTE: 37 C.F.R. 1.28(b) requires "Notification of any change in loss of entitlement to small entity status must be filed in the application . . . prior to paying, or at the time of paying . . . issue fee." From the wording of 37 C.F.R. § 1.28(b): (a) notification of change of status must be made even if the fee is paid as "other than a small entity" and (b) no notification is required if the change is to another small entity.

[ ] 37 C.F.R. § 1.492(e) and (f) (surcharge fees for filing the declaration and/or filing an English translation of an International Application later than 30 months after the priority date).



SIGNATURE OF PRACTITIONER

Reg. No.: 25,858

WILLIAM R. EVANS
(type or print name of practitioner)

Tel. No.: (212)708-1930

LADAS & PARRY
P.O. Address

Customer No.: 00140

26 WEST 61ST STREET
NEW YORK, N.Y. 10023

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Brian Herbert BEECH et al

Serial No: Art Unit:

Filed: Examiner:

For: METHOD AND APPARATUS FOR REDUCING DISTORTION OF DIGITAL DATA

Attorney Docket No.:U 013409-5

Commissioner of Patents and Trademarks
Washington, D.C. 20231 Dated APRIL 19, 2001

Sir,

PRELIMINARY AMENDMENT

Please amend the application as follows:

CERTIFICATE UNDER 37 CFR 1.10

I hereby certify that this paper is being deposited with the United States Postal Service on this date APRIL 19, 2001 in an envelope as "EXPRESS MAIL POST OFFICE TO ADDRESSEE" Mailing Label Number EL 728212401 US addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231

BARBARA SANTIAGO

(Type or print name of person mailing paper)

Barbara D. Santiago

(Signature of person mailing paper)

NOTE: Each paper or fee referred to as enclosed herein has the number of the "EXPRESS MAIL" mailing label placed thereon prior to mailing 37 CFR 1.16(b).

EXPRESS MAIL LABEL NO.: EL 728212401 US

IN THE CLAIMS

3. (amended) The method of claim 1, wherein said signal (19) is applied to a forward model (21) representative of the distortion of the satellite transmission link (5 - 7), an output of the forward model is added with said signal to provide an error signal, said error signal is amplified and further summed with said signal to provide an input to a next succeeding stage.

4. (amended) The method of claim 1, wherein said signal is passed through an initial approximator prior to passage through successive approximation stages.

6. (amended) The method of claim 1, wherein the signal is modulated in accordance with 16 QAM.

7. (amended) The method of claim 1, wherein the signal is modulated in accordance with 32 QAM.

8. (amended) The method of claim 1, wherein the signal is modulated in accordance with 16 PSK.

11. (amended) A link as claimed in claim 9, wherein each pre-distorting stage (12) includes a forward model (21) representative of the distortion of the satellite transmission link (5 - 7) arranged to receive said signal (19), a summer (23) for adding an output of said forward model with said signal to provide an error signal, an amplifier (24) for amplifying said error signal, and an

output of said amplifier being applied to a further summer (25) for adding an output of said amplifier with said signal, wherein an output of said further summer (25) may be applied as input to a forward model (27) of a next succeeding stage.

14. (amended) A link as claimed in claim 9, wherein the signal is modulated in accordance with 16 QAM.

15. (amended) A link as claimed in claim 9, wherein the signal is modulated in accordance with 32 QAM.

16. (amended) A link as claimed in claim 9, wherein the signal is modulated in accordance with 16 PSK.

Respectfully submitted

IAIN C. BAILLIE
Registration No. 24090

Claim 3 (amended)

The method of claim 1 [or 2], wherein said signal (19) is applied to a forward model (21) representative of the distortion of the satellite transmission link (5 - 7), an output of the forward model is added with said signal to provide an error signal, said error signal is amplified and further summed with said signal to provide an input to a next succeeding stage.

Claim 4 (amended)

The method of [any preceding claim] claim 1, wherein said signal is passed through an initial approximator prior to passage through successive approximation stages.

Claim 6 (amended)

The method of [any preceding claim] claim 1, wherein the signal is modulated in accordance with 16 QAM.

Claim 7 (amended)

The method of [any of claims 1 to 5] claim 1, wherein the signal is modulated in accordance with 32 QAM.

Claim 8 (amended)

The method of [any of claims 1 to 5] claim 1, wherein the signal is modulated in accordance with 16 PSK.

Claim 11 (amended)

A link as claimed in claim 9 [or 10], wherein each pre-distorting stage (12) includes a forward model (21) representative of the distortion of the satellite transmission link (5 - 7) arranged to receive said signal (19), a summer (23) for adding an output of said forward model with said signal to provide an error signal, an amplifier (24) for amplifying said error signal, and an output of said amplifier being applied to a further summer (25) for adding an output of said amplifier with said signal, wherein an output of said further summer (25) may be applied as input to a forward model (27) of a next succeeding stage.

Claim 14 (amended)

A link as claimed in [any of claims 9 to 13] claim 9, wherein the signal is modulated in accordance with 16 QAM.

Claim 15 (amended)

A link as claimed in [any of claims 9 to 13] claim 9, wherein the signal is modulated in accordance with 32 QAM.

Claim 16 (amended)

A link as claimed in [any of claims 9 to 13] claim 9, wherein the signal is modulated in accordance with 16 PSK.

PATENT COOPERATION TREA[illegible] U 013409-5

From the INTERNATIONAL BUREAU

PCT

To:

MOLYNEAUX, Martyn W.
Langner Parry
52-54 High Holborn
London WC1V 6RR
ROYAUME-UNI

NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

Date of mailing (day/month/year)	
22 November 2000 (22.11.00)	
Applicant's or agent's file reference	**IMPORTANT NOTIFICATION**
P/23694.WO/MWM	
International application No.	**International filing date** (day/month/year)
PCT/GB99/03425	22 October 1999 (22.10.99)

1. The following indications appeared on record concerning:

[X] the applicant [ ] the inventor [ ] the agent [ ] the common representative

Name and Address	State of Nationality	State of Residence
TANDBERG TELEVISION LIMITED 35 Basinghall Street London EC2V 5DB United Kingdom	GB	GB
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

CORRECTED VERSION

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

[ ] the person [X] the name [X] the address [X] the nationality [X] the residence

Name and Address	State of Nationality	State of Residence
TANDBERG TELEVISION ASA Philip Pedersens Vei 20 P.O. Box 322 N-1326 Lysaker Norway	NO	NO
	Telephone No.	
	Facsimile No.	
	Teleprinter No.	

3. Further observations, if necessary:

4. A copy of this notification has been sent to:

[X] the receiving Office
[ ] the International Searching Authority
[X] the International Preliminary Examining Authority
[ ] the designated Offices concerned
[X] the elected Offices concerned
[ ] other:

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Mougamadou ABIDINE
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338 83.38

Form PCT/IB/306 (March 1994) 003676245

EXPRESS MAIL LABEL NO.: EL 728212401 US

METHOD AND APPARATUS FOR REDUCING DISTORTION OF DIGITAL DATA

This invention relates to the transmission of digital data, and in particular to method and apparatus for reduction of distortion incurred by representations of digital data during passage through transmission links.

It is well known in the field of transmission of digital data, and particularly for transmission of data concerning digital broadcast material, for modulation techniques to use symbols, arranged as points in a particular constellation pattern, to represent digital data. Typical techniques are those of Phase Shift Keying (PSK) and Quadrature Amplitude Modulation (QAM). Two of the more common schemes of these techniques are those of Quadrature PSK (QPSK), e.g. digital satellite transmission for "direct to home" applications, and 8PSK for e.g. satellite news gathering applications. There is a recognised desire to utilise higher order modulation schemes, such as 16 PSK and 16QAM. This will allow transmission at a higher bit rate, thus providing the opportunity to carry a greater number of channels within the pre-defined bandwidth of a particular transmission link.

Transmission of a modulated signal through transmission links such as terrestrial, satellite or cable links results in a distortion of the signal. This distortion is due, in part at least, to the non-linear effects of passage of a signal through the transmission link. Distortion leads to a change in location of the constellation points of any given modulation scheme. An increase in the order of modulation results in a decrease in the distance between constellation points, and so leads to a higher probability of distortion leading to errors occurring during the demodulation of higher order modulation schemes.

Prior art methods used to reduce the effects of distortion by non-linear component(s) within transmission links include use of at least partially compensating pre-correction. One approach is that of feed-forward, where the non-linear output of an amplifier is sampled, and compared with the

required signal prior to transmission, with the resultant error being subtracted from the amplifier output. This approach is only suitable for systems in which the pre-distorter and amplifier are co-located. Thus, where this technique is used for satellite transmission links the opportunity for introduction or modification of the pre-distorter to take account of changes in amplifier characteristics is severely limited.

Another technique is that of constellation pre-distortion, where the constellation points generated by the modulator are pre-distorted such that at the amplifier output the constellation points are located in their correct relative positions. This method is suitable only for transmission links that are memory-less. This precludes the use of this approach where pulse shaping takes place before non-linear amplification of the signal. Therefore, it is not suitable for those transmission links that include band pass filtering of the signal.

Signal pre-distortion performed at the radio (RF), intermediate (IF) or base band frequencies is often carried out by application of an inverse function of the distortion to the signal. This type of pre-correction generates out of band components, which are then carried through to the amplifier input. Where the amplifier has an input filter, as is common for amplifiers used in satellite transmission links, then these components may be removed from the signal which becomes the input to the amplifier. Thus, the distortion imposed by the amplifier will not be accurately corrected as the amplifier input signal is not the entire transmitted signal. This means that this form of pre-correction is not effective for correction of amplifiers contained within satellite transponders where the bandwidth of the incoming signal is high in relation to the bandwidth of the transponder. Additionally, for digital transmission using higher order modulation schemes, this type of pre-correction requires very high clocking rates in order to generate the wide-band pre-distortion components.

It is an object of the present invention to overcome at least some of the problems associated with the prior art.

According to this invention there is provided a method of pre-distortion a signal, modulated to carry symbols representative of digital data, so as to offset later distortion of the signal during transmission across a transmission link, the method comprising passing the signal through a cascade of pre-distorting stages, each of which generates an approximation of the required pre-distortion, each successive stage receiving the approximation from the preceding stage so that the errors in successive approximations converge.

According to a second aspect of this invention there is provided apparatus for pre-distortion of a signal, modulated to carry symbols representative of digital data, so as to offset later distortion of the signal during transmission across a transmission link, the apparatus comprising a cascade of pre-distorting stages, each of which generates an approximation of the required pre-distortion, each successive stage receiving the approximation from the preceding stage so that the errors in successive approximations converge.

The method and apparatus of this invention allows input of a complex signal at a rate as low as one sample per symbol to the pre-distorter, and generating at its output a complex signal which may be at the same rate. This means that implementation of the hardware is practical for systems operating at higher symbol rates.

The method and apparatus of the invention are particularly suited to pre-distortion of a modulated signal which is subsequently transmitted through a satellite transmission link as it provides a ground based means of applying pre-distortion of the amplifier located on the satellite.

It is common for transmission links to include band pass filters between the means of modulating the signal and the amplifier. As is described above, such filters are known to remove at least substantial portions of any out of band components contained within a signal. Additionally, this invention provides accurate pre-distortion for transmission links having one or more band pass filter regardless of the location of such filter(s). Satellite

transmission links commonly employ ground and satellite-based band pass filters.

The method and apparatus of this invention allows accurate pre-distortion for a transmission link carrying any constellation pattern and having any non-linear amplifier, irrespective of whether the link is memory-lessor not.

This allows pre-distortion to be applied to a signal for subsequent transmission through a transmission link having a band pass filter at each of the transmitter and receiver ends of the link. Additionally, by taking past and future symbols of the signal into account, not only can the static positions of the constellation points be pre-distorted accurately to take account of the effects of passage through the non-linearity of the link, but also the effects of inter-symbol interference (i.e. smearing) are substantially reduced.

The invention will now be described by way of example only and with reference to the following figures:

Figure 1 is a schematic diagram of a satellite transmission system incorporating a satellite transmission link.

Figure 2 is a schematic diagram of a pre-distorter of the present invention.

Figure 3 is a schematic diagram of the distorting function FM1 of Figure 2.

Figure 4 is a representation of an ideal 16QAM constellation prior to transmission through a transmission link.

Figure 5 is a representation of the output from a receiving Nyquist filter corresponding to the transmission link input of Figure 4.

Figures 6a to 6d show computer simulations of representations of outputs from the TWT of Figure 5 using differing number of stages of successive approximation.

Figure 7 is a graphical comparison of Bit Error Rates of differing pre-distortion circumstances.

Figures 8a and 8b show the output of a receiver Nyquist filter for 32 QAM using a pre-distorter of the invention, and the corresponding constellation at the input to a transmitter Nyquist filter respectively.

Figure 9 shows the computer simulation of an output spectrum, for the TWT of Figure 5 comparing the pre-distortion of this invention with the output without use of pre-distortion.

Figure 10 is a schematic diagram of a feedback control loop.

In Figure 1 there is shown a satellite transmission link 1, having a root Nyquist band-pass filter 2, IQ modulator 3 and up-converter 4 prior to a transmitter 5. The transmitter provides an uplink to a satellite 6, which in turn provides a downlink to a number of receivers, one of which is shown as receiver 7. The receiver end of the satellite transmission link 1 can be be seen as a reverse of the transmission end, with the receiver 7 connected successively through a down-converter 8, an IQ demodulator 9 and a root Nyquist band-pass filter 10.

During operation of the transmission link 1, an input base band frequency signal, being one which has been modulated by a particular technique and scheme such as 16 QAM and having I and Q complex components, is filtered by the root Nyquist band-pass filter 2. It is usual to use Nyquist filtering within transmission links in order to constrain the bandwidth of the transmitted signal. Conveniently Nyquist filtering of the signal is conducted by root Nyquist filters placed at each of the transmitter and receiver ends of the

transmission link. Nyquist and root Nyquist filters impose a linear distortion upon the modulated signal.

Each of the I and Q components of the root Nyquist filtered signal are provided as inputs to the IQ modulator 3 such that the input to up-converter 4 is a modulated carrier which represents the digital data of the chosen modulation scheme. The up-converter changes the frequency of the input signal to a higher frequency than base band. The higher frequency signal is transmitted to satellite 6, where it is received by the satellite's transponder (not shown), amplified by a travelling wave tube amplifier (TWT) and retransmitted from the transponder to a plurality of receivers 7. The transponder is often constructed such as to ensure that the transponder input is passed through band-pass filters before and after being amplified by the TWT. Band-pass filters include the characteristic of not allowing out of band components to pass through the filter.

On receipt of the transponder output by receiver 7 the signal is processed by each of down-converter 8, IQ demodulator 9 and root Nyquist filter 10 to provide an output from the transmission link 1 in the form of a base band frequency signal having I and Q components. This output is then subsequently demodulated to obtain the digital data transmitted by the symbols within the modulation scheme.

In addition to the satellite transmission link 1, Figure 1 also shows a pre-distorter 12 located prior to the transmission link 1. The pre-distorter is adapted to operate in accordance with the invention of this application, and arranged to apply pre-distortion to an incoming signal to compensate for the distortion subsequently applied to that signal during its passage through the satellite transmission link 1.

Figure 2 is a block diagram of the pre-distorter 12 in greater detail. It is assumed that all signals (input to, output from and within the pre-distorter) are complex signals. However, it will be understood by those skilled in the art

that in a practical implementation these signals could be in the form of either cartesian or polar representation. The input signal 19 to the pre-distorter 12 is fed from junction 20 to a forward model of a distorting function 21 to supply symbols representative of digital data for time = t(1). The output 22 of this forward model is input along with the input signal 19 (which is arranged to be symbols representative of digital data for time = t(1) by use of unshown delay apparatus) to summing node 23. The output of summing node 23 is scaled by a value A by multiplier 24. The output of multiplier 24 is combined with input signal 19 (also arranged to supply symbols representative of digital data for time = t(1) by use of unshown delay apparatus) to summing node 25 to provide an output 26 from the first stage of approximation. This output 26 is determined by equation (1) given below.

Output 26 = (input 19)*A – (output 22)*A + (input 19)

Output 26 = [(input 19) – (output 22)]*A + (input 19) Equation 1

[(input 19) – (output 22)] is the error which exists between output 22 and input 19, and therefore

Output 26 = (input 19) – (error *A) Equation 2

It will be understood that Output 26 concerns symbols representative of digital data for time = t(1).

Output 26 acts as the input to forward model 27 of the second stage of successive approximations, and is the same as input 19 to the first stage, but modified by the error scaled by a factor A. It can be seen that the pre-distorter 12 generates an error for symbols representative of digital data for time = t(1) in relation to the output of forward model 21 of the first stage of the successive approximations but the correction to account for pre-distortion is applied in relation to the input to forward model 27 of the next stage. During passage of symbols representative of digital data for time = t(1) through the second stage of successive approximation, the first stage of successive approximation is

supplied at junction 20 with symbols representative of digital data for time = t(1+n) where n represents the pipeline delay.

It can be shown that with a suitable choice of A the use of successive approximations such as given in the pre-distorter 12 of Figure 2 then the output of the pre-distorter will converge towards zero error as more stages of successive approximation are added. In practice A is chosen to achieve the highest convergence rate for a given FM1. For a transmission link such as that of Figure 1, then it has been found that six stages of successive approximation strikes a reasonable balance between convergence towards zero error and hardware implementation of the pre-distorter. Optionally, pre-distorter 12 may additionally include an initial approximator 28. This initial approximator is arranged to operate function IM1, which is a function arranged to provide an output which is approximately the inverse of FM1 as implemented by forward models 21, 27 and their equivalents in further successive stages. Where initial approximator 28 is included within a pre-distorter 12, then output 29 is provided as an input to forward model 21 and instead of input 19 fed from junction 20. This is arranged to ensure (through use of appropriate delays to operate for symbols representative of digital data for time = t(1) as described above. Thus equation (2) becomes

Output 26 = (Output 29) – error *A Equation 3

For pre-distortion of an amplifier such as a TWT, the approximation function IM1 may be a function which places the constellation points in the correct place for pre-distortion but which does not dynamically change their position from symbol to symbol. This is known as a static pre-distortion. Using a static pre-distortion for a rough approximation substantially reduces the number of successive approximation stages required. Typically one static correction stage plus three dynamic stages (implemented by passage through one successive approximation stage) is sufficient to attain the desired pre-distortion of a satellite transmission link such as that of Figure 1.

The distorting function FM1 for the transmission link 1 of Figure 1 may be of the form shown in Figure 3. This consists of a forward TWT model 30, with root Nyquist filters 31 and 32 placed before and after the model. It is the presence of the root Nyquist filters which enables the pre-distorter 12 to correct for the signal transitions from one constellation point to another. The practical implementation of the root Nyquist filters enables the summation of scaled sample values. The sample values include both past and future samples. This is the mechanism that enables correction for the effects of distortion upon symbols which rely upon past and future symbols for their later interpretation during demodulation, i.e. the dynamic distortion. When used in combination with successive approximation this allows for a substantial reduction in the effects of inter-symbol interference.

The method and apparatus of this invention can be adapted in the manner exemplified in this embodiment so as not to generate out of band components. Instead, the non-linear correction components are folded back into the bandwidth of the signal, and thus provide accurate pre-distortion for transmission links having one or more band pass filters.

If it is required that the pre-distorter shall correct additionally for the uplink High Power Amplifier (HPA), then a forward HPA model can also be included in FM1. Alternatively, a completely separate pre-distorter could be used.

As an example of the operation of a pre-distorter, some simulation results are given in Figs 4 to 9. In this example A=0.875 = 7/8. The use of simple fractions with a binary denominator reduces hardware complexity. A Nyquist link with 35% roll-off factor is included.

Fig 4 shows an ideal 16QAM constellation 5 to be transmitted with the corner points placed at TWT saturation and Fig 5 shows the corresponding output from a typical TWT. The constellation points are displaced and additionally they are smudged due to the transition affects caused by the transmit Nyquist filter /TWT combination.

Figures 6a to 6d show the results corresponding to outputs of successive pre-distorter stages. It can be seen, when comparing the results of Figure 6a with those of Figure 5 (no correction by means of a pre-distorter), that passage through just one stage of successive approximation leads to an improvement in the dynamic distortion imposed by a satellite link such as that of Figure 1. The result can be improved by adding further pre-distorter successive approximation stages, as can be seen by comparison of the results of Figures 6b to 6d.

Use of greater numbers of successive approximation stages leads to all points, except for the four corner points, becoming nearer to being substantially ideal following passage through each additional successive approximation stage. The corner points, which are at TWT saturation, exhibit a comet tail effect. This is due to the fact that, at these points, the gain of the TWT is zero and perfect convergence is not possible. Nevertheless the link Bit Error Rate (BER) approaches that of the linear link.

Fig 7 shows a comparison of a satellite transmission link BER for various uncoded modulations with static and dynamic pre-distortion should be noted.

Line 70 represents the BER for a signal modulated by 8PSK and transmitted through a transmission link having no non-linear distortion. Thus, this is also the ideal signal output BER of a transmission link following passage through a pre-distorter. Line 71 represents the same ideal for the different modulation scheme of 16QAM. Line 72 demonstrates the BER of a signal having been modulated by 8PSK and being pre-distorted by the prior art technique of static pre-distortion. Graph lines 73 and 74 represent the BERs of the 16QAM modulated signals having static and dynamic pre-distortion, and static only pre-distortion respectively. It should be noted that a 16QAM modulated signal subjected to both static and dynamic pre-distortion demonstrates better performance than a signal modulated by 8PSK and pre-distorted by the prior art techniques of static only pre-distortion. As explained earlier, higher order

modulation schemes are inherently more susceptible to increased BER due to the decreasing distance between constellation points. Figure 7 thus demonstrates the significant increase in performance associated with use of the pre-distortion method and apparatus of this application.

32 QAM is particularly suited to pre-distortion in accordance with this invention because the corner points are missing and all the remaining points pre-correct well. Fig 8a shows the output from a satellite transmission link TWT with pre-distortion using 6 stages of dynamic pre-distortion only. A=0.875 and 35% roll off factor. The corner points that are missing would be at the saturation point of the TWT if they were present. Fig 8b shows the pre-distorter output, which is a 32QAM constellation to be transmitted through a satellite transmission link. Fig 9 shows the output spectrum from the uplink for the case with and without pre-distortion. It is clear that in both cases the spectrum follows the shape of the transmit Nyquist filter and the only difference is that the pre-distorted signal is about 3dB lower in power.

In the above description it has been assumed that the characteristics of the TWT are known and these parameters are programmed into the pre-distortion hardware.

Figure 10 illustrates a block diagram of a feedback control loop, which includes a satellite of satellite transmission link 1, for modification of the pre-distortion parameters of FM1 of Figure 3.

The pre-distorter 100 receives its control parameters from microprocessor 101. The required non-linear characteristics are generated by the microprocessor and are down-loaded into RAM in the pre-distorter. Two modes are possible. In the non-feedback mode, it is assumed that the parameters for a particular satellite are known and these are stored in memory 102. The accuracy of pre-distortion will be limited by the accuracy of these parameters.

In the feedback mode, the satellite output is received by receiver 103 and the constellation analyser 104 generates error signals, which correspond to the displacement of the constellation points. For 16QAM for example the constellation points fall on three circles, so a magnitude and phase error estimate may be made for each of the three circles. The error signals are processed by a software algorithm implemented in the microprocessor to generate updates of the control parameters passed to the pre-distorter.

It will be realised that the time delay of the return path to the satellite is approximately 0.25 seconds, and so the update time of the control parameters must be equal or longer than this delay. However, in practice the TWT parameters will only be slowly varying.

In the feedback mode described above, no training sequence is required. However, if the parameters of the satellite TWT are not known, then the constellation from the TWT may be so distorted that the tracking feedback loop cannot pull into lock.

One solution for this is to add a training sequence into the transmission. An alternative method is to provide a separate training signal. When the up-link is first operational into the satellite, a set up mode in the modulator generates a training signal, which may not be of the same modulation type as the intended transmission. The micro-processor runs an algorithm to calculate the required correction parameters based on the signal from receiver 103. Subsequent to this procedure, transmission of the intended transmission may start and the feedback mode accurately maintains the control parameters. In the case of intermittent loss of the received signal, the corrector continues to correct accurately because the most recent control parameters are stored in memory 102.

Claims

1 A method of pre-distorting a signal, modulated to carry symbols representative of digital data , so as to offset later distortion of the signal during transmission across a transmission link, the method comprising passing the signal through a cascade of pre-distorting stages, each of which generates an approximation of the required pre-distortion, each successive stage receiving the approximation from the preceding stage so that errors in successive approximations converge.

2 The method of Claim 1 applied to pre-distorting a signal to be transmitted across a transmission link having a particular bandwidth wherein the signal is passed through a cascade of pre-distorting stages, each of which generates an approximation within the said bandwidth.

3 The method of each of Claims 1 or 2 further comprising passing of the signal through an initial approximator prior to its passage through successive approximation stages.

4 The method of Claim 3 wherein the initial approximator comprises a static pre-distortion approximation function.

5 The method of any of the preceding claims wherein method is adapted for transmission of the signal across a satellite transmission link.

6 The method of any preceding claim wherein the signal is modulated in accordance with 16 QAM.

7 The method of any of Claims 1 to 5 wherein the signal is modulated in accordance with 32 QAM.

8 The method of any of Claims 1 to 5 wherein the signal is modulated in accordance with 16 PSK.

9 The method of Claim 5 wherein the satellite of the satellite transmission link comprises an Travelling Wave Tube amplifier.

10 The method of Claim 5 wherein the satellite transmission link includes a Nyquist filter.

11 The method of Claim 10 wherein the Nyquist filter comprises root Nyquist filters.

12 Apparatus for pre-distortion of a signal, modulated to carry symbols representing digital data, so as to offset later distortion of the signal during transmission across a transmission link, the apparatus comprising a cascade of pre-distorting stages, each of which generates an approximation of the required pre-distortion, each successive stage receiving the approximation from the preceding stage so that the errors in successive approximations converge.

13 Apparatus according to Claim 12 applied such as to pre-distort a signal to be transmitted across a transmission link having a particular bandwidth, having a cascade of pre-distorting stages, each of which generates an approximation within the said bandwidth.

14 The apparatus of Claim 13 further comprising an initial approximator.

15 Apparatus of Claim 14 wherein the initial approximator comprises a static pre-distortion approximation model.

16 Apparatus according to any of preceding Claims 12 to 15 wherein the apparatus is adapted for transmission of the signal across a satellite transmission link.

17 The apparatus of any of preceding Claims 12 to 16 wherein the signal is modulated in accordance with 16 QAM.

18 The apparatus of any of preceding Claims 12 to 16 wherein the signal is modulated in accordance with 32 QAM.

19 Apparatus of any of preceding Claims 12 to 16 wherein the signal is modulated in accordance with 16 PSK.

20 The apparatus of Claim 16 wherein the satellite of the satellite transmission link comprises an Tunnel Wave Tube amplifier.

21 The apparatus of Claim 16 wherein the satellite transmission link includes a Nyquist filter.

22 The apparatus of Claim 21 wherein the Nyquist filter comprises root Nyquist filters.

23 The apparatus of Claim 12 adapted for use in accordance with Claim 22 and comprising five successive approximation stages.

24 The apparatus of Claim 15 adapted for use in accordance with Claim 22 and comprising three successive approximation stages.

25 The apparatus of Claim 16 further comprising a feedback control loop.

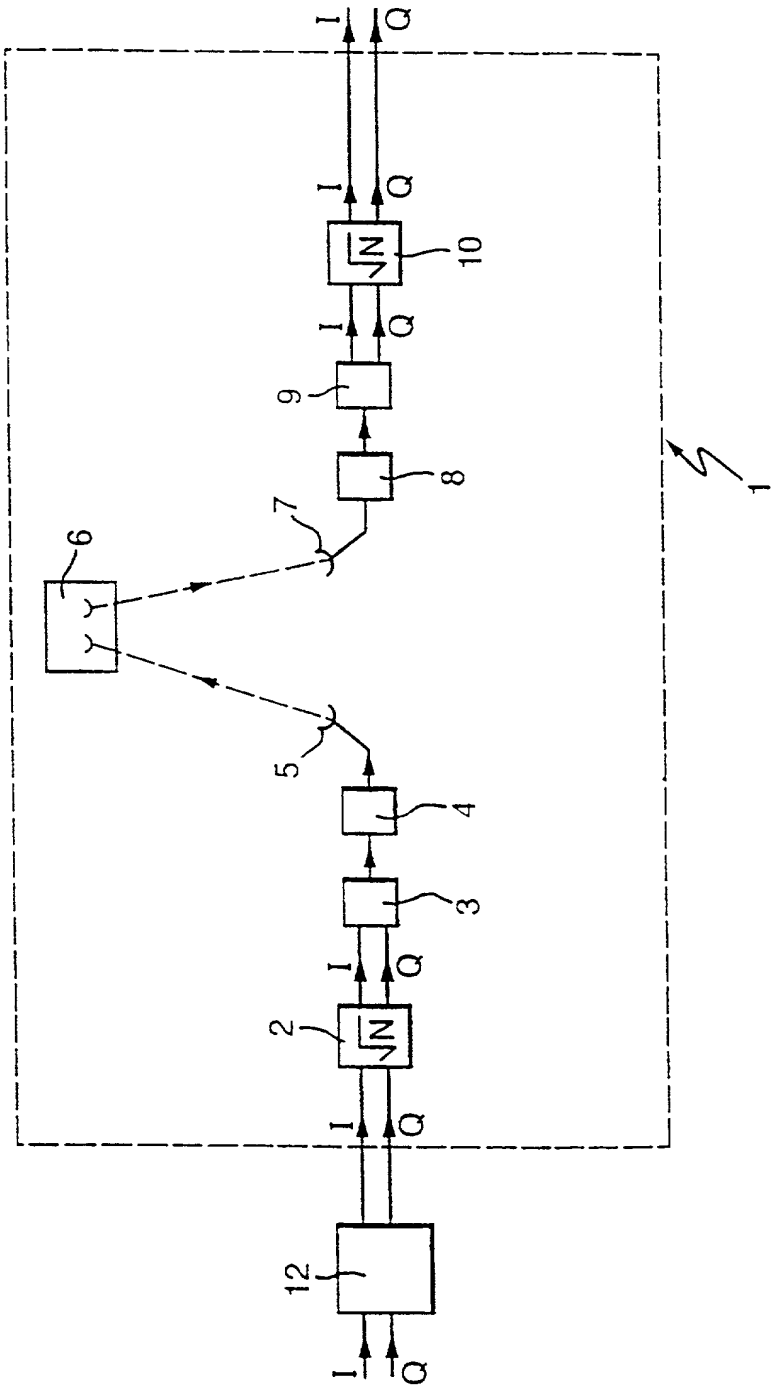
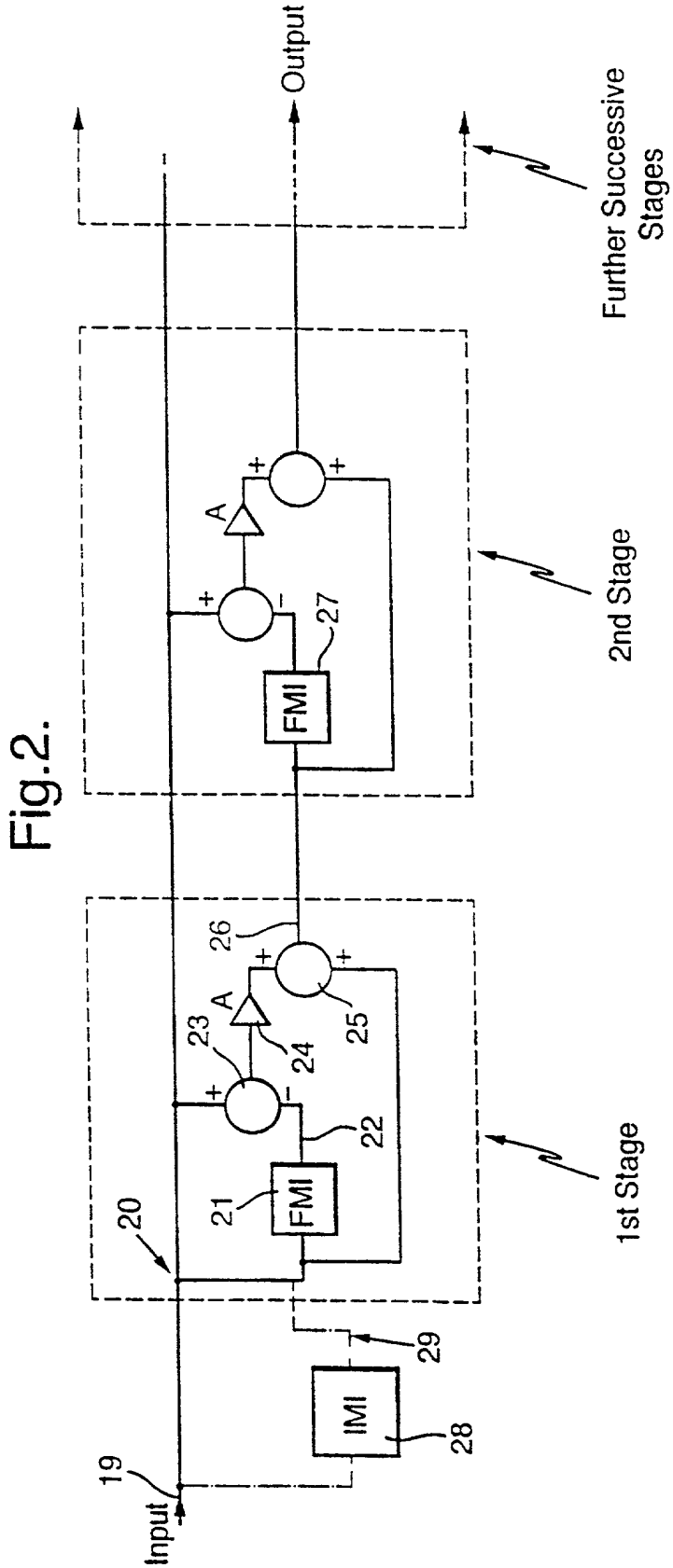


Fig.1.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Further Successive Stages
2nd Stage
1st Stage
Input
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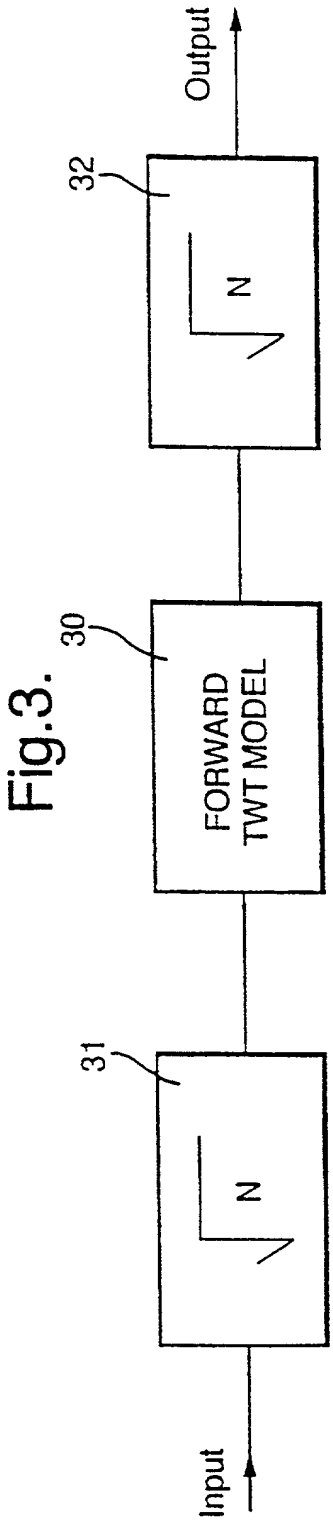
21
22
23
24
25
26
27
28
29
A
FMI
IMI

Fig.2.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N
30
FORWARD TWT MODEL
31
N
Input

Fig.3.

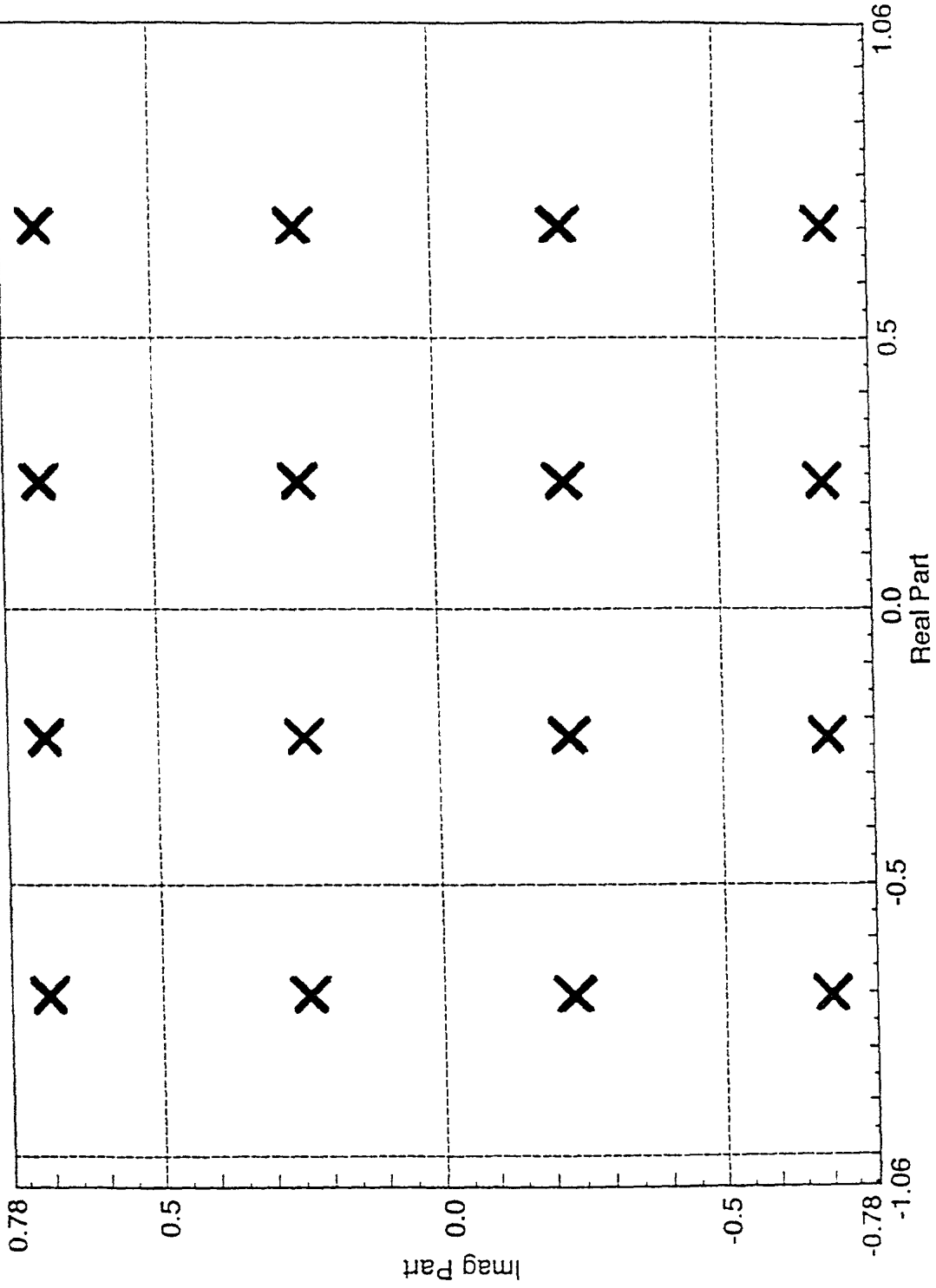


Fig.4.

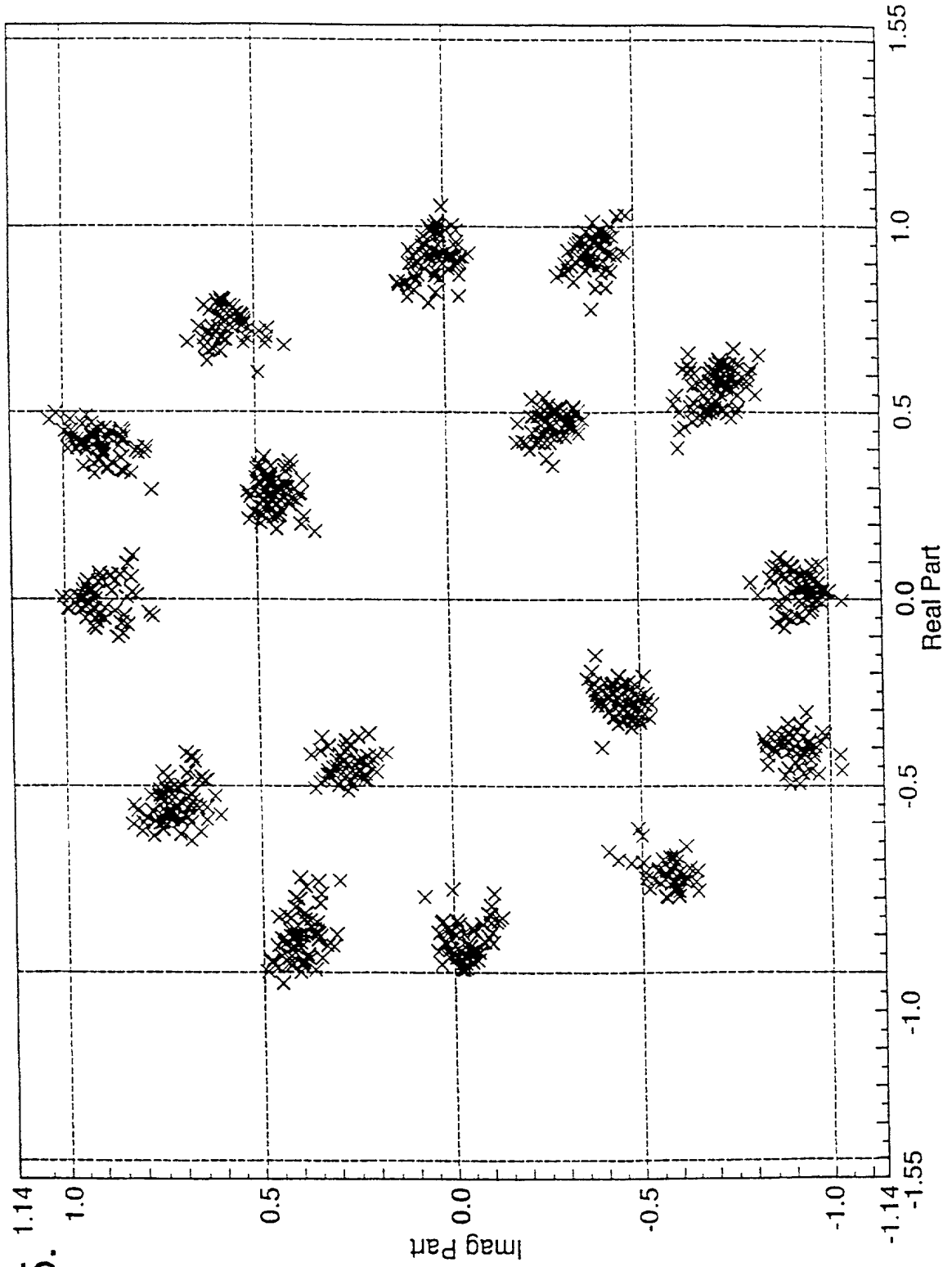


Fig.5.

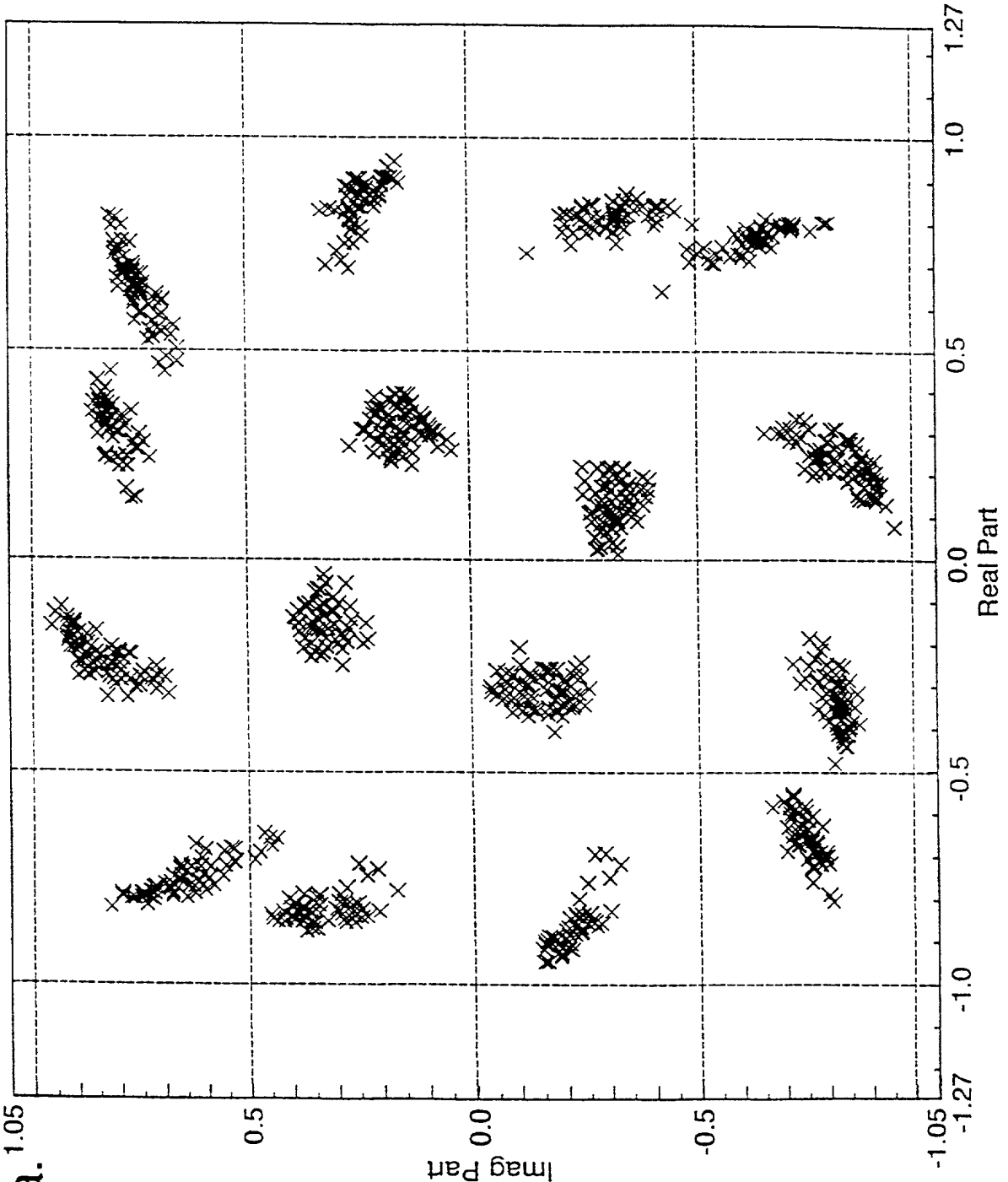


Fig.6a.

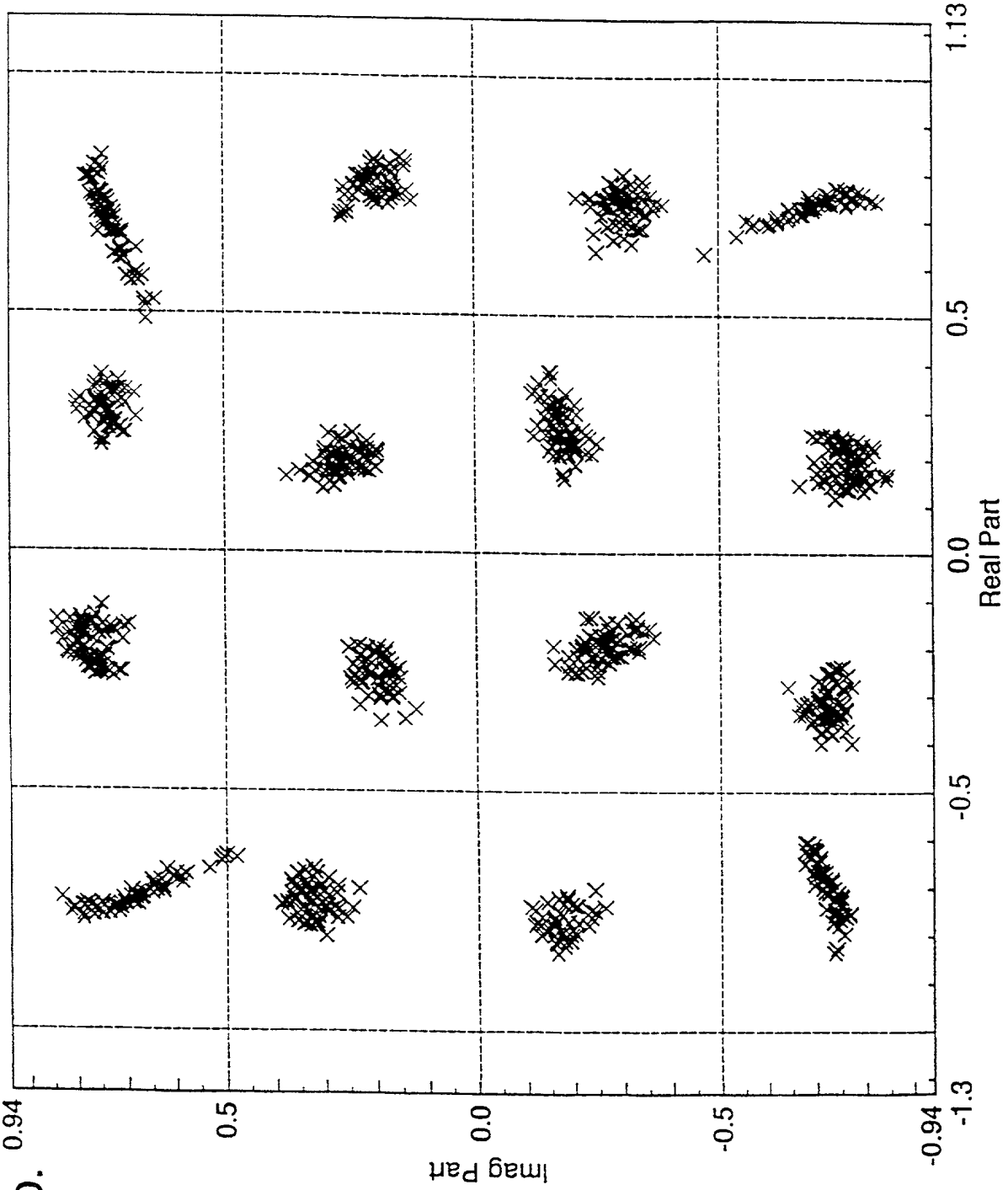


Fig.6b.

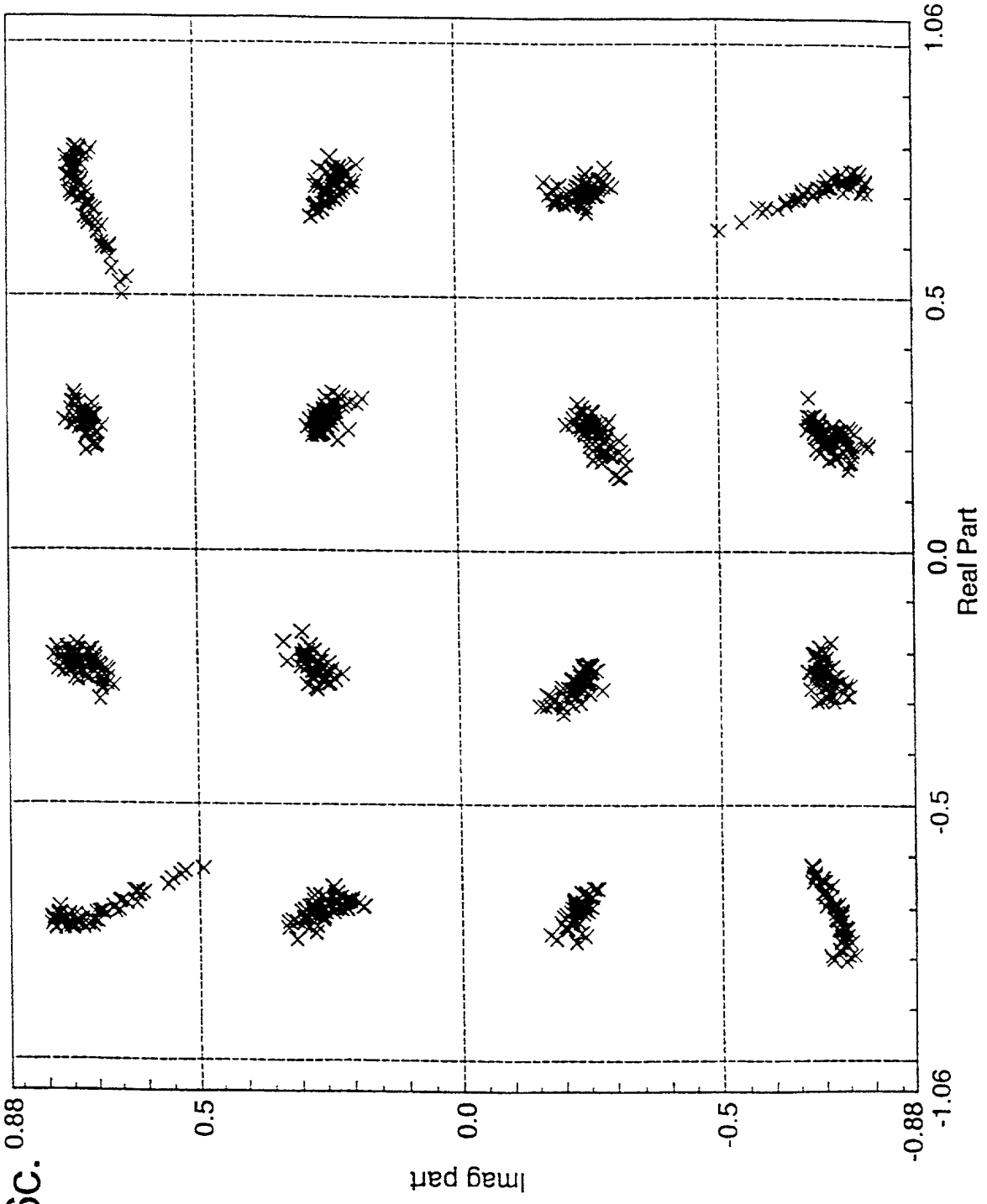


Fig.6c.

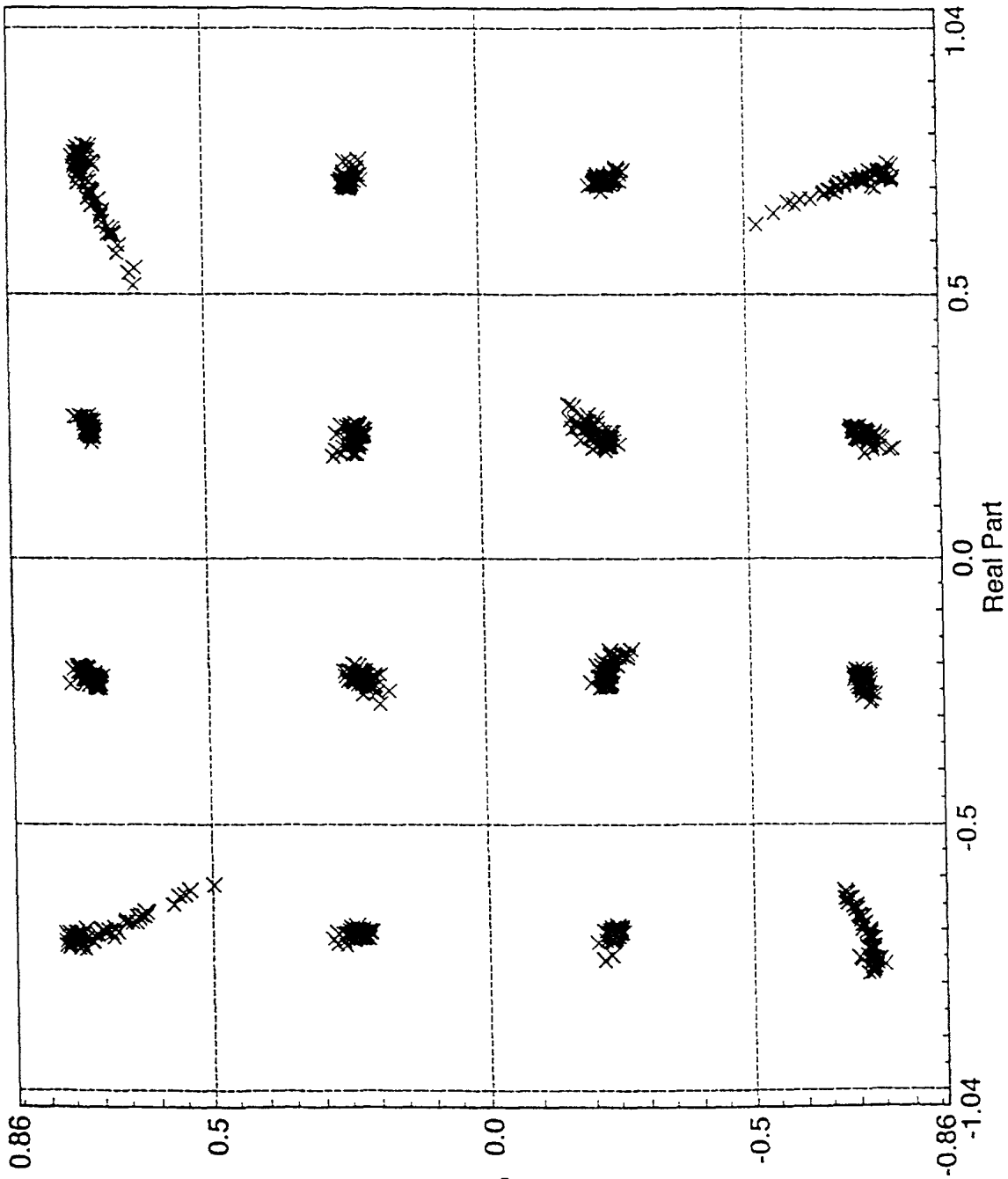
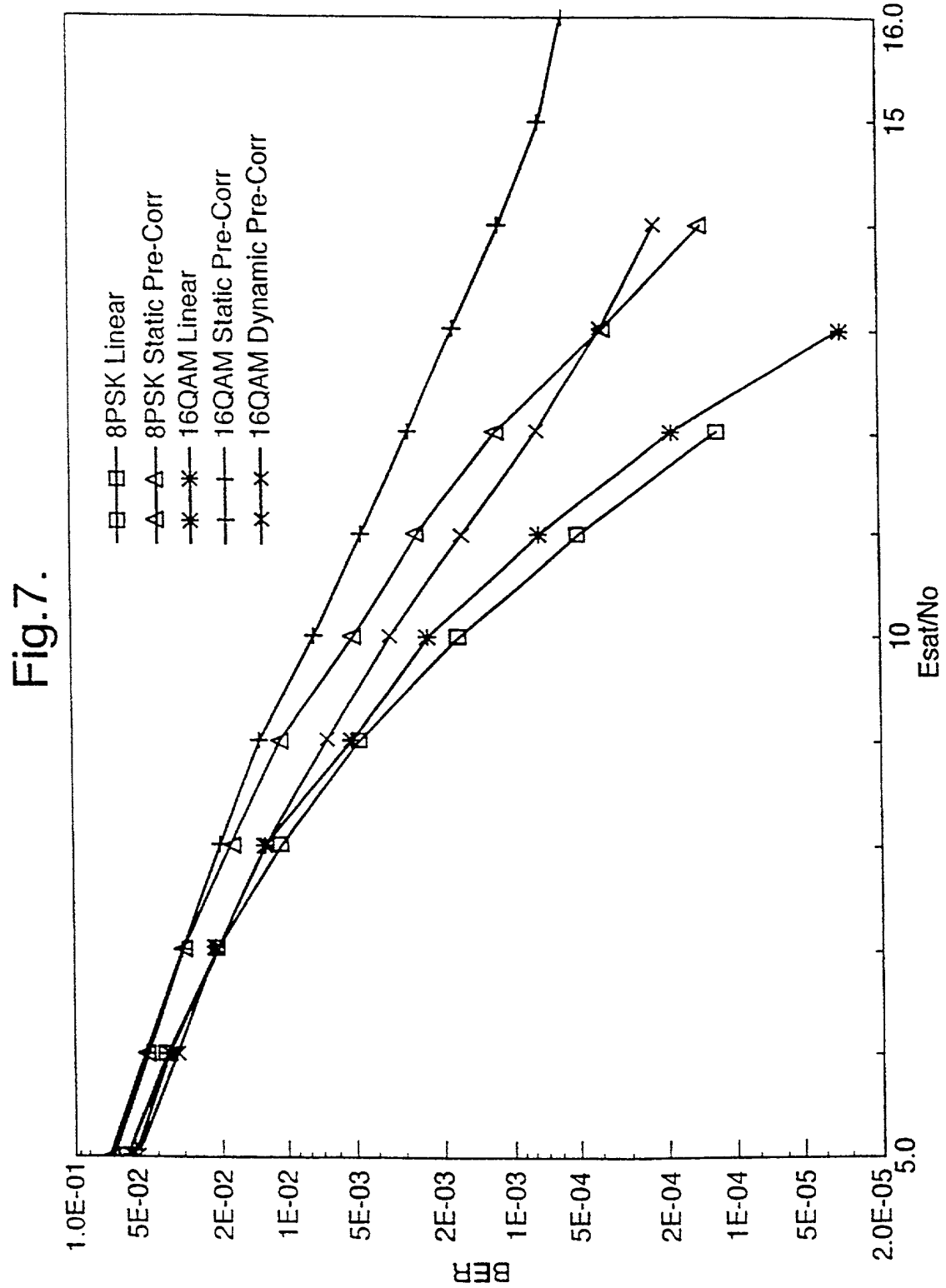


Fig.6d.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8PSK Static Pre-Corr
16QAM Linear
16QAM Static Pre-Corr
16QAM Dynamic Pre-Corr
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1E-02
5E-03
2E-03
1E-03
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10
15
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Esat/No

Fig.7.

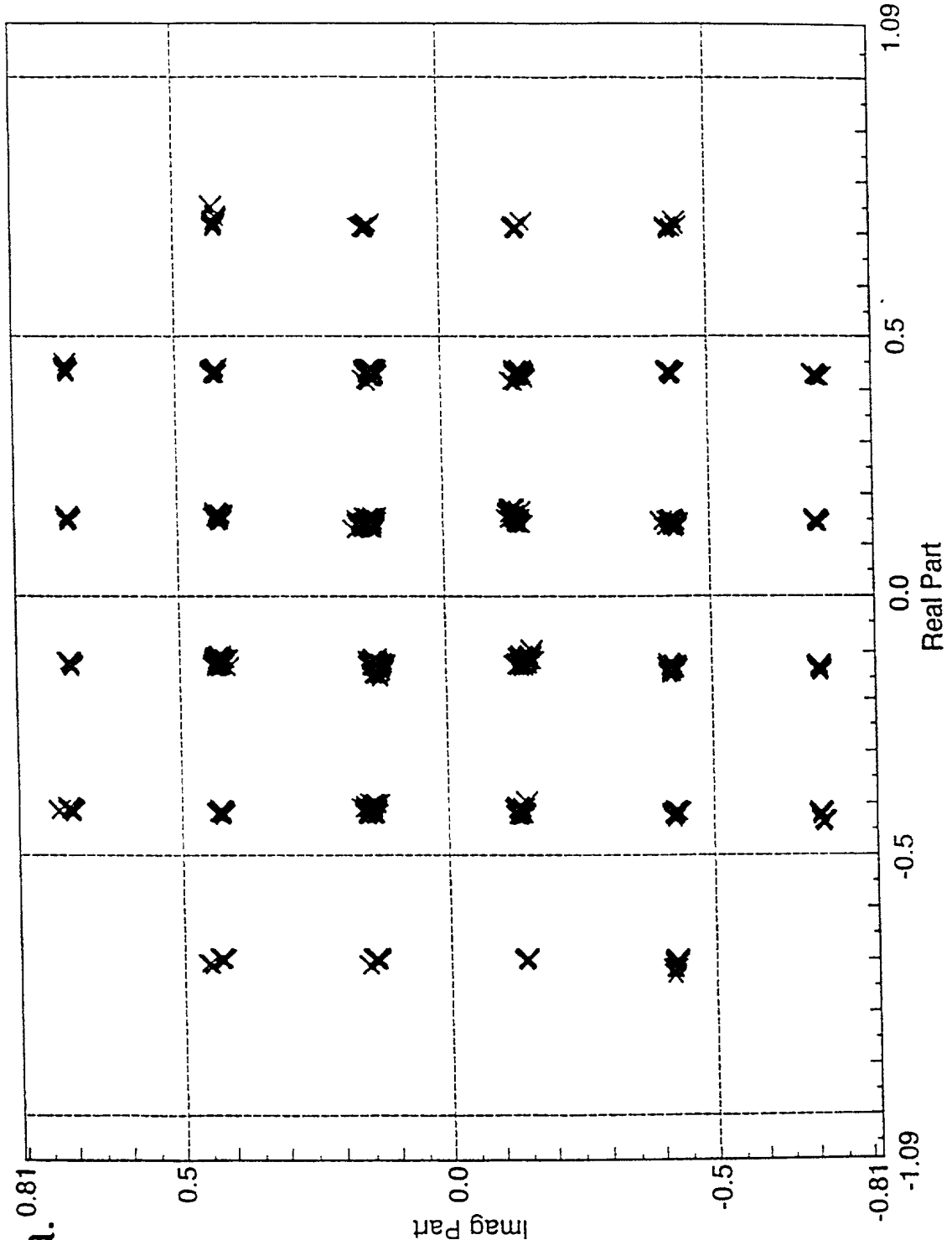


Fig.8a.

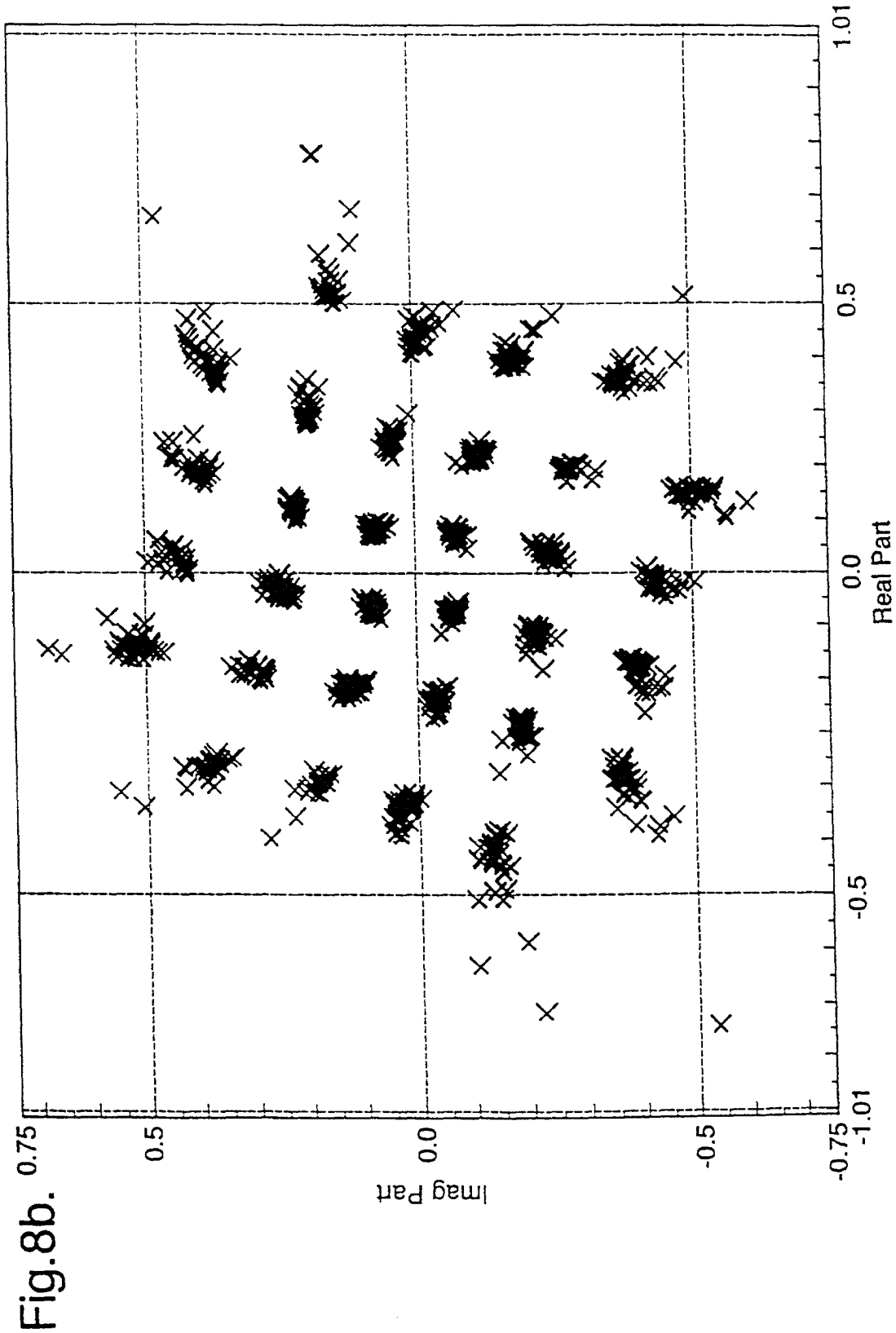
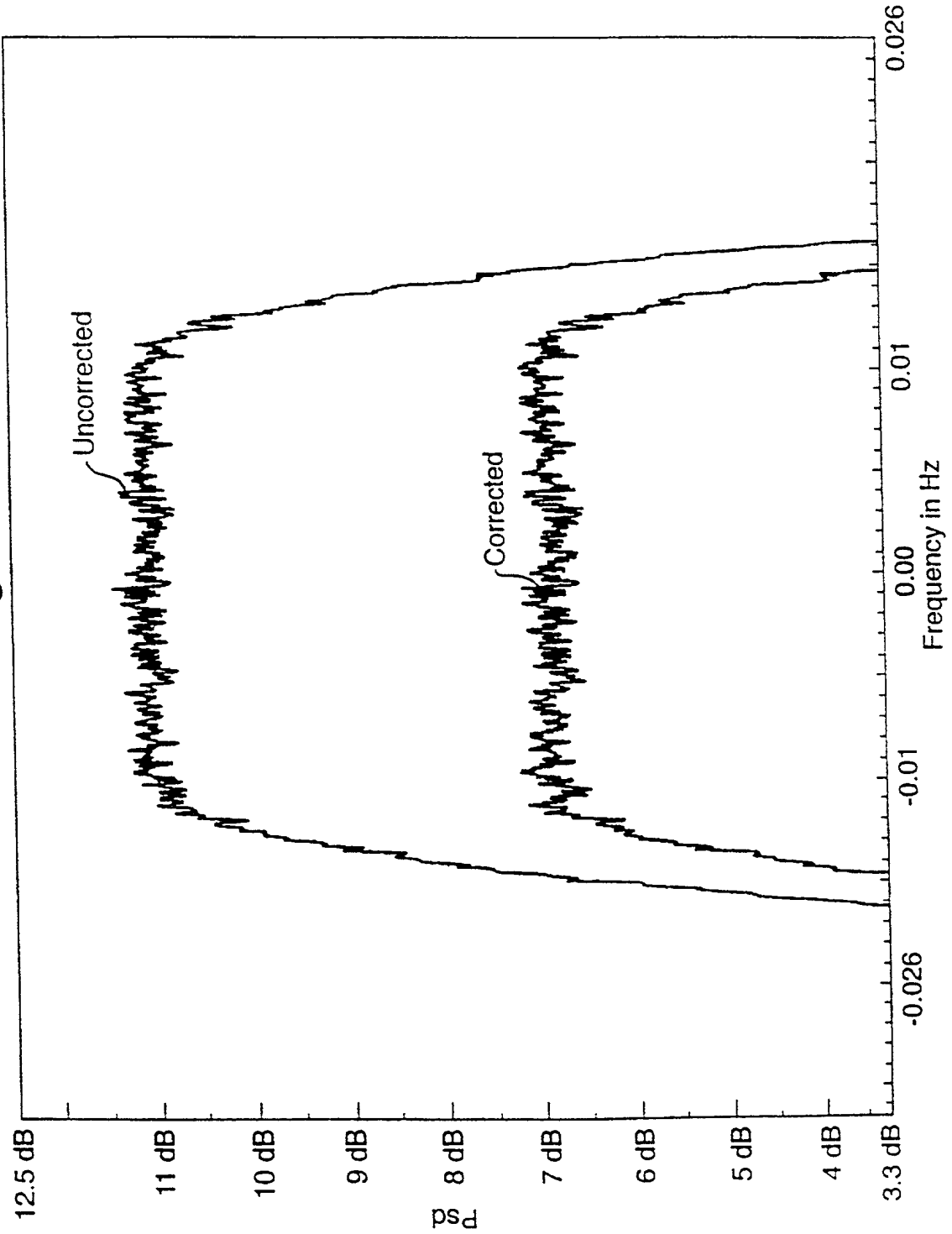


Fig.8b.

Fig.9.


Uncorrected
Corrected
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11 dB
10 dB
9 dB
8 dB
7 dB
6 dB
5 dB
4 dB
3.3 dB
Psd
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Frequency in Hz

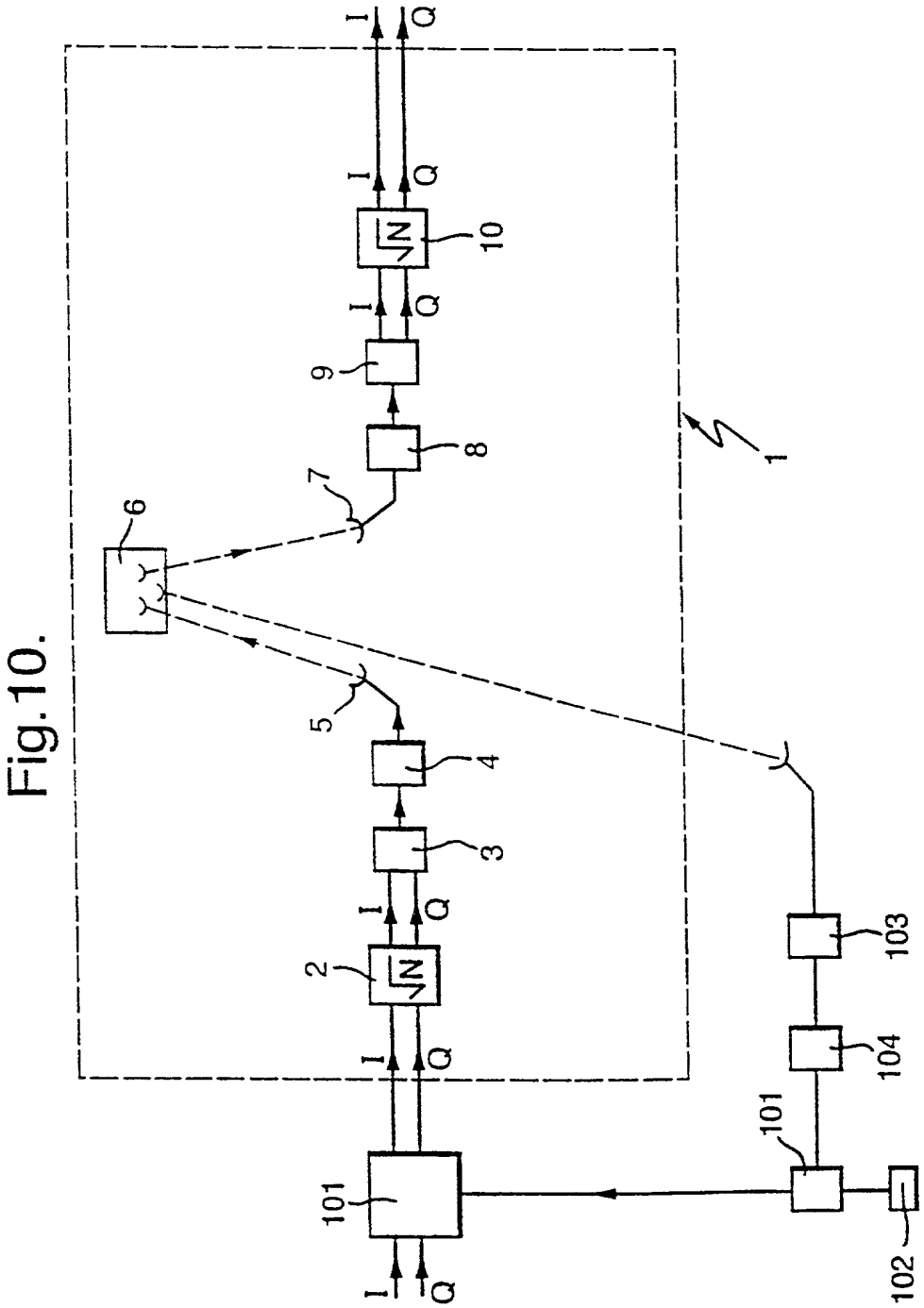

Fig.10.

Practitioner's Docket No. U 013409-5 ***PATENT***

COMBINED DECLARATION AND POWER OF ATTORNEY

(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT, SUPPLEMENTAL, DIVISIONAL, CONTINUATION, OR C-I-P)

As a below named inventor, I hereby declare that:

TYPE OF DECLARATION

This declaration is of the following type:

(check one applicable item below)

[ ] original.
[ ] design.
[ ] supplemental.

NOTE: If the declaration is for an International Application being filed as a divisional, continuation or continuation-in-part application, do not check next item; check appropriate one of last three items.

[X] national stage of PCT.

NOTE: If one of the following 3 items apply, then complete and also attach ADDED PAGES FOR DIVISIONAL, CONTINUATION OR C-I-P.

NOTE: See 37 C.F.R. § 1.63(d) (continued prosecution application) for use of a prior nonprovisional application declaration in the continuation or divisional application being filed on behalf of the same or fewer of the inventors named in the prior application.

[ ] divisional.
[ ] continuation.

NOTE: Where an application discloses and claims subject matter not disclosed in the prior application, or a continuation or divisional application names an inventor not named in the prior application, a continuation-in-part application must be filed under 37 C.F.R. § 1.53(b) (application filing requirements-nonprovisional application).

[ ] continuation-in-part (C-I-P).

INVENTORSHIP IDENTIFICATION

WARNING: *If the inventors are each not the inventors of all the claims, an explanation of the facts, including the ownership of all the claims at the time the last claimed invention was made, should be submitted.*

My residence, post office address and citizenship are as stated below, next to my name. I believe that I am the original, first and sole inventor *(if only one name is listed below)* or an original, first and joint inventor *(if plural names are listed below)* of the subject matter that is claimed, and for which a patent is sought on the invention entitled:

EXPRESS MAIL LABEL NO.: EL 728212401 US

METHOD AND APPARATUS FOR REDUCING DISTORTION OF DIGITAL DATA

SPECIFICATION IDENTIFICATION

The specification of which:

(complete (a), (b), or (c))

(a) [ ] is attached hereto.

NOTE: "The following combinations of information supplied in an oath or declaration filed on the application filing date with a specification are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 C F.R. § 1.63:

"(1) name of inventor(s), and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration on filing,

"(2) name of inventor(s), and attorney docket number which was on the specification as filed; or

"(3) name of inventor(s), and title which was on the specification as filed."

Notice of July 13, 1995 (1177 O.G. 60).

(b) [ ] was filed on _______________, [ ] as Application No. ___________
[ ] and was amended on ___________________________________ *(if applicable).*

NOTE: Amendments filed after the original papers are deposited with the PTO that contain new matter are not accorded a filing date by being referred to in the declaration. Accordingly, the amendments involved are those filed with the application papers or, in the case of a supplemental declaration, are those amendments claiming matter not encompassed in the original statement of invention or claims. See 37 C.F.R. § 1.67.

NOTE: "The following combinations of information supplied in an oath or declaration filed after the filing date are acceptable as minimums for identifying a specification and compliance with any one of the items below will be accepted as complying with the identification requirement of 37 C.F.R. § 1.63:

"(1) name of inventor(s), and application number (consisting of the series code and the serial number; e.g.,08/123,456);

"(2) name of inventor(s), serial number and filing date;

"(3) name of inventor(s) and attorney docket number which was on the specification as filed;

"(4) name of inventor(s), title which was on the specification as filed and filing date;

"(5) name of inventor(s), title which was on the specification as filed and reference to an attached specification which is both attached to the oath or declaration at the time of execution and submitted with the oath or declaration; or

"(6) name of inventor(s), title which was on the specification as filed and accompanied by a cover letter accurately identifying the application for which it was intended by either the application number (consisting of the series code and the serial number; e.g.,08/123,456), or serial number and filing date. Absent any statement(s) to the contrary, it will be presumed that the application filed in the PTO is the application which the inventor(s) executed by signing the oath or declaration."

Notice of July 13, 1995 (1177 O.G. 60), M.P.E.P. § 601(a), 6th ed., rev.3.

(c) [X] was described and claimed in PCT International Application No. PCT/GB99/03425 filed on 22 October 1999 and as amended under PCT Article 19 on _____ *(if any)*.

SUPPLEMENTAL DECLARATION (37 C.F.R. § 1.67(b))

(complete the following where a supplemental declaration is being submitted)

[ ] I hereby declare that the subject matter of the

[ ] attached amendment
[ ] amendment filed on _____.

was part of my/our invention and was invented before the filing date of the original application, above identified, for such invention.

ACKNOWLEDGMENT OF REVIEW OF PAPERS AND DUTY OF CANDOR

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information, which is material to patentability as defined in 37, Code of Federal Regulations, § 1.56,

(also check the following items, if desired)

[ ] and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable Examiner would consider it important in deciding whether to allow the application to issue as a patent, and

[ ] in compliance with this duty, there is attached an information disclosure statement, in accordance with 37 C.F.R. § 1.98.

PRIORITY CLAIM (35 U.S.C. § 119(a)-(d))

NOTE: "The claim to priority need be in no special form and may be made by the attorney or agent if the foreign application is referred to in the oath or declaration as required by § 1.63. The claim for priority and the certified copy of the foreign application specified in 35 U.S.C. § 119(b) must be filed in the case of an interference (§ 1.630), when necessary to overcome the date of a reference relied upon by the examiner, when specifically required by the examiner, and in all other situations, before the patent is granted. If the claim for priority or the certified copy of the foreign application is filed after the date the issue fee is paid, it must be accompanied by a petition requesting entry and by the fee set forth in § 1.17(i). If the certified copy is not in the English language, a translation need not be filed except in the case of interference; or when necessary to overcome the date of a reference relied upon by the examiner; or when specifically required by the examiner, in which event an English language translation must be filed together with a statement that the translation of the certified copy is accurate." 37 C.F.R. § 1.55(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(complete (d) or (e))

(d) [ ] no such applications have been filed.
(e) [X] such applications have been filed as follows.

NOTE: Where item (c) is entered above and the International Application which designated the U.S. itself claimed priority check item (e), enter the details below and make the priority claim.

PRIOR FOREIGN/PCT APPLICATION(S) FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS APPLICATION AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. § 119(a)-(d)

COUNTRY (OR INDICATE IF PCT)	APPLICATION NUMBER	DATE OF FILING DAY, **MONTH**, YEAR	PRIORITY CLAIMED UNDER 35 USC 119
United Kingdom	9823190.5	23 October 1998 (23.10.98)	[X] YES [ ] NO
			[ ] YES [ ] NO
			[ ] YES [ ] NO
			[ ] YES [ ] NO
			[ ] YES [ ] NO

CLAIM FOR BENEFIT OF PRIOR U.S. PROVISIONAL APPLICATION(S)
(35 U.S.C. § 119(e))

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below:

PROVISIONAL APPLICATION NUMBER	FILING DATE
/ _____	_____
/ _____	_____
/ _____	_____

CLAIM FOR BENEFIT OF EARLIER U.S./PCT APPLICATION(S) UNDER 35 U.S.C. § 120

[ ] The claim for the benefit of any such applications are set forth in the attached ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR CONTINUATION-IN-PART (C-I-P) APPLICATION.

ALL FOREIGN APPLICATION(S), *IF ANY,* FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

NOTE: If the application filed more than 12 months from the filing date of this application is a PCT filing forming the basis for this application entering the United States as (1) the national stage, or (2) a continuation, divisional, or continuation-in-part, then also complete ADDED PAGES TO COMBINED DECLARATION AND POWER OF ATTORNEY FOR DIVISIONAL, CONTINUATION OR C-I-P APPLICATION for benefit of the prior U.S or PCT application(s) under 35 U.S.C. § 120.

POWER OF ATTORNEY

I hereby appoint the following practitioner(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

(list name and registration number)

JOSEPH H. HANDELMAN, 26179

JOHN RICHARDS, 31053

RICHARD J. STREIT, 25765

PETER D. GALLOWAY, 27885

IAN C. BAILLIE, 24090

THOMAS F. PETERSON, 24790

RICHARD P. BERG, 28145

JULIAN H. COHEN, 20302

WILLIAM R. EVANS, 25858

JANET I. CORD, 33778

CLIFFORD J. MASS, 30086

CYNTHIA R. MILLER, 34678

(Check the following item, if applicable)

[ ] I hereby appoint the practitioner(s) associated with the Customer Number provided below to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

[ ] Attached, as part of this declaration and power of attorney, is the authorization of the above-named practitioner(s) to accept and follow instructions from my representative(s).

SEND CORRESPONDENCE TO

Ladas & Parry
26 West 61st Street
New York, N.Y. 10023

DIRECT TELEPHONE CALLS TO:
(Name and telephone number)

DECLARATION

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

SIGNATURE(S)

NOTE: Carefully indicate the family (or last) name, as it should appear on the filing receipt and all other document.

NOTE: Each inventor must be identified by full name, including the family name, and at least one given name without abbreviation together with any other given name or initial, and by his/her residence, post office address and country of citizenship. 37 C.F.R. § 1.63(a)(3).

NOTE: Inventors may execute separate declarations/oaths provided each declaration/oath sets forth all the inventors. Section 1.63(a)(3) requires that a declaration/oath, inter alia, identify each inventor and prohibits the execution of separate declarations/oaths which each sets forth only the name of the executing inventor. 62 Fed. Reg. 53,131, 53,142, October 10, 1997,

1-00

Full name of sole or first inventor

Brian Herbert BEECH
(Given Name) (Middle Initial or Name) Family (Or Last Name)

Inventor's signature Brian H Beech

Date 1 December 2000 **Country of Citizenship** United Kingdom

Residence 10 Darlington Road, Bishopstoke, Eastleigh, Southampton, Hampshire, SO50 0NF, United Kingdom GBN

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■■■■■■

Full name of second joint inventor, if any

2-00

David EDWARDS
(Given Name) (Middle Initial or Name) Family (Or Last Name)

Inventor's signature D Edwards

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■■■■■■

(check proper box(es) for any of the following added page(s) that form a part of this declaration)

[ ] **Signature** for fourth and subsequent joint inventors. *Number of pages added* _____

* * *

[ ] **Signature** by administrator(trix), executor(trix) or legal representative for deceased or incapacitated inventor. *Number of pages added* _____

* * *

[ ] **Signature** for inventor who refuses to sign or cannot be reached by person authorized under 37 C.F.R. § 1.47. *Number of pages added* _____

* * *

[ ] Added page for **signature** by one joint inventor on behalf of deceased inventor(s) where legal representative cannot be appointed in time. (37 C.F.R. § 1.47)

* * *

[ ] Added pages to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (C-I-P) application.

[ ] Number of pages added

* * *

[ ] Authorization of practitioner(s) to accept and follow instructions from representative.

(If no further pages form a part of this Declaration, then end this Declaration with this page and check the following item)

[X] This declaration ends with this page.